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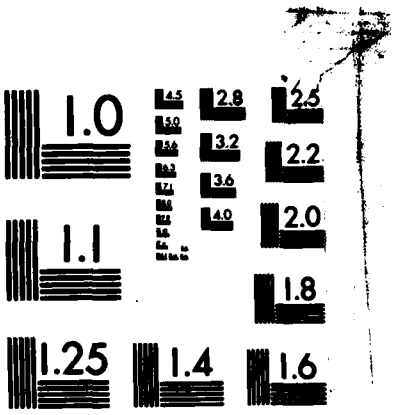

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FINAL REPORT PFTR-1088-83-10
Contract NO. N000 14-80-C-0780
October 1983

INTEGRATING RESEARCH ON PERCEIVED AND ACCEPTABLE RISK WITHIN THE PSYCHOMETRIC PARADIGM

Prepared For:
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1.0 Long-Range Objectives of this Project

Research on perceived and acceptable risk has two main objectives. One is to develop an understanding of the fundamental laws governing individuals' perceptions and their behaviors in situations of risk. The second is to help individuals and society make better decisions about risks. We believe that these two objectives, one descriptive and the other prescriptive, are complementary. Descriptive knowledge will help us understand and forecast how people will react to the prescriptive guidelines put forth by experts. Such understanding will help us determine whether resistance to risk policies determined by analytic methods such as cost-benefit or decision analysis is due to misperceptions of risks and misunderstanding of these analyses or whether it is due to the failure of these analyses to give proper consideration to the characteristics of risky situations that people consider to be important. Finally, the ability to describe individuals' preferences (or values) and beliefs is needed for the implementation of formal methods like decision analysis.

2.0 Specific Objective

2.1 The Psychometric Paradigm

A major approach to the study of perceived and aceptable risk has employed psychophysical scaling methods and multivariate analysis to produce quantitative representations of people's attitudes and perceptions. Researchers employing this "psychometric paradigm" have typically asked people to judge the current and desired riskiness (or safety) of diverse sets of hazardous activities, substances, and technologies, and to indicate their desires for risk reduction and regulation of these hazards. These global judgments are then related to judgments about other properties, including: (1) the hazard's

status on characteristics that have been hypothesized to account for risk perceptions and attitudes (e.g., voluntariness, dread, knowledge, controllability); (ii) the benefits that each hazard provides to society; (iii) the number of deaths caused by the hazard in an average year; (iv) the number of deaths caused by the hazard in a disastrous year; and (v) the seriousness of each death from a particular hazard relative to a death due to other causes.

2.2 Project Objectives

The specific goals of this project were to:

- develop an integrated perspective on current research within the psychometric paradigm;
- identify the consistent substantive conclusions emerging from current and past research;
- enhance the effectiveness of current research programs;
- set the stage for better communication and increased collaboration among researchers in the future; and
- identify future research needs and establish priorities for future research.

3.0 Project Accomplishments

3.1 Risk Perception Workshop

The focal point of the project was a workshop held in Eugene, Oregon on December 11-13, 1980, which brought researchers in this field together for intensive discussions of key methodological and substantive issues in risk perception research.

The participants in the workshop are listed in Table 1. They were carefully selected to include the major contributors to research within the psychometric paradigm. They were psychologists, with the exception of Otway

(engineering), Hohenemser (physics), Tiemann and Gould (sociology), Green (architecture), Brown (mathematics), and MacLean (philosophy). J. R. Simpson of the Office of Naval Research and Marshall Robinson of the Russell Sage Foundation also attended the workshop in the role of observers.

Insert Table 1 about here

Prior to the workshop, the participants were asked to prepare and distribute background papers. These papers were not intended to be polished reports. Their purpose was to provide detailed summaries of the author's research accompanied by an assessment of the relationship of this work to that of others in the field and a list of questions and issues to be discussed at the workshop.

The Agenda for the workshop is presented in Table 2. The first 1-1/4 days contained presentations by researchers giving overviews of their work. The remaining sessions began by examining substantive issues involving methodology (What hazards should be studied? What people and groups should be studied? What sorts of questionnaire tasks should be employed? What aspects of hazards should be examined? How should the data be analyzed?). Next came discussions of the substance of the research findings and their relevance for policy making. A detailed list of the discussion topics is contained in the second part of the Agenda (Table 2).

Insert Table 2 about here

3.2 Workshop Conclusions and Products

The intensive discussions at the workshop led to a number of general conclusions followed by a lively exchange of written papers that were

subsequently published in the journal, Risk Analysis. The major conclusions were as follows:

1. Most psychometric studies have been based on correlations among mean ratings of risk and risk characteristics across different technologies. If robust, the relationships revealed this way should be indicative of how society as a whole responds to hazards. They may also reflect the perceptions of most individuals looking at a set of hazards. However, Gould and others at the workshop argued that such relationships need not hold true at the level of individual respondents evaluating a single technology. For example, just because technologies judged to be relatively high in catastrophic potential also tend to be judged as high in risk does not mean that those persons who see a specific technology as particularly catastrophic will also perceive it as relatively risky. Understanding the relationships at this level may help explain why certain individuals exhibit a high degree of concern about a particular technology. The participants recommended that research of this type be undertaken. Although some such studies are now underway, it is too early to tell what they will find.

2. The characteristics of hazards (e.g., dread, controllability, voluntariness) that have served as inputs to psychometric analyses have typically been generated by the researchers on the basis of hypotheses in the literature. The workshop participants recommended that studies be done in which the characteristics of importance would be generated by the respondent with minimal cueing by the researcher. The repertory grid (Green & Brown, 1980; Perusse, 1980), is a method that could be used for this purpose. Respondents are shown three hazards and asked to indicate in what way two of them are similar to each other and different from the third. The charac-

teristics by which similarities and differences are defined become candidates for consideration as important aspects of perceived risk.

The repertory grid can be viewed as a member of a larger class of free-response techniques, which allow respondents to generate their own response alternatives. Earle and Lindell (in press) have recently used such techniques to survey public perceptions of hazardous industrial facilities. Although many of their results replicate those from studies using structured response alternatives, they found some potentially important new findings. One was that their respondents failed to exhibit concern for future generations, in contrast to the concern shown in factor analytic studies and in all moral treatments of this topic.

3. Early psychometric studies relied on factor analysis to determine people's mental representations of perceived risk. The participants in the workshop felt strongly that the set of techniques used in these studies needed to be broadened to include multidimensional scaling, tree representations and other multivariate methods. Since the workshop, some important steps have been taken in this direction by Johnson and Tversky (in press), MacGill (1982) and others. Their work shows that different methods produce different representations. If these differences prove to be reliable, then great care will be needed to choose the method most suitable to the purposes of particular research projects. Factor analytic represenations have been found to predict certain important attitudes towards hazards such as desire for regulation or perceived seriousness of an accident (Slovic, Fischhoff & Lichtenstein, 1983). Johnson and Tversky hypothesize that multidimensional scaling or tree representations, based on similarity judgments, may predict other responses, such as reactions to new risks or new evidence about risks (e.g., the effect of

Tylenol poisoning on the purchase of over-the-counter drugs). In addition, factor analyses conducted on diverse sets of items may miss "local" features pertinent to only a few hazards. Similarity judgments allow consideration of features that experimenters may have missed. However, similarity may be influenced by superficial or irrelevant considerations (e.g., electric power and nuclear power may be judged "similar" in "risk" because they are both sources of power).

4. The workshop participants argued that the groups of people studied should be broadened to include large-scale surveys of the general population and special populations of interest (hazard victims, those who live near hazardous facilities, legislators, journalists, activists, and cross-national populations). Much of this broader sampling is currently underway, in studies being conducted by workshop participants. Gould, Tiemann, Gardner and their colleagues at Yale are studying activists. Lindell anad Earle have been examining the perception of science writers, environmentalists and persons living at various distances from hazardous industrial sites. We at Decision Research are currently working with a group of Hungarian social scientists on a cross-national comparison of risk perception.

5. On the substantive side, workshop participants seemed to agree that one of the most important contributions of research to date has been to demonstrate the inadequacy of the unidimensional indices (e.g., annual probability of death, loss of life expectancy) that have often been advocated for "putting risks in perspective" and aiding decision making. Psychometric studies suggest that such comparisons will be unsatisfactory because people's perceptions are determined not only by mortality statistics, but also by a variety of quantitative and qualitative characteristics. These include a

hazard's degree of controllability, the dread it evokes, its catastrophic potential, and the equity of its risk/benefit distribution. Attempts to characterize, compare, and regulate risks must be sensitive to the broader conception of risk that underlies people's concerns. Fischhoff, Watson, and Hope (1983) have made a start in this direction by demonstrating how one might go about constructing a more adequate definition of risk. They show that variations in the scope of one's definition of risk can greatly change the assessment of risk from various energy technologies.

3.3 Workshop Product: A Forum on Policy Implications

The social and policy implications of risk perception research were the subject of lively debate at the workshop, stimulated by a background paper written by Harry Otway. This paper, "Reflections on Risk Perception and Policy," was particularly critical of the field, arguing that risk research is being used as a tool in a discourse which is not concerned with risk per se, nor with perceptual and cognitive processes, but with the legitimacy of decision-aking institutions and the equitable distribution of risks and benefits.

This paper was judged to be important enough for the editor of the journal Risk Analysis to use it as a centerpiece for an entire issue of the journal, devoted to the topic of Risk Analysis, Risk Management, and the Social and Behavioral Sciences (see Table 3).

Insert Table 3 about here

We attempted to counter Otway's cynical view with a paper, "Why Study Risk Perception," published as part of the forum in Risk Analysis and attached as an appendix to this report. The paper summarizes many of the substantive

findings of risk perception research and expresses our view that understanding how people think about risk plays an important role in guiding policy, even if it cannot resolve all questions. Behavioral studies of flood-insurance decisions and seatbelt usage have already provided policy relevant insights. Psychometric studies provide the beginnings of a psychological classification system for hazards that may help explain and forecast reactions to specific technologies such as nuclear power or genetic engineering (Slovic, Fischhoff & Lichtenstein, 1982) or provide guidelines for managing the social conflicts surrounding hazardous technologies (von Winterfeldt & Edwards, 1983).

In sum, the workshop played a vital role in bringing together many of the leading participants in risk-perception research. The forum in Risk Analysis is one testimony to the lively and important debates that took place at the workshop. The longer-term legacy of this project will result from research, currently being conducted around the world, designed to answer the questions raised in the workshop.

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von Winterfeldt, D. & Edwards, W. Patterns of conflict about risky technologies. Unpublished manuscript, Social Science Research Institute, University of Southern California, 1983.

Table 1

Participants in the Risk Perception Workshop

Gordon Bechtel, Dept. of Marketing, Univ. of Florida, Gainesville, Florida

Richard Brown, Dept. of Mathematics, Univ. of Dundee, Dundee, Scotland, U.K.

David Buss, Inst. of Personality Assess. & Res., U. of Calif., Berkeley, Ca.

Gerald Cole, Survey Research Ctr., Univ. of Michigan, Ann Arbor, Mich.

Kenneth Craik, Inst. of Personality Assess. & Res., U. of Calif., Berkeley,Ca.

Karl Dake, Inst. of Personality Assess. & Res., U. of Calif., Berkeley, Ca.

Timothy Earle, Battelle Human Affairs Research Ctr., Seattle, Wash.

Baruch Fischhoff, Decision Research, A Branch of Perceptronics, Eugene, Ore.

Gerald Gardner, Inst. for Social & Policy Studies, Yale Univ., New Haven, Ct.

Leroy Gould, Inst. for Social & Policy Studies, Yale Univ., New Haven, Ct.

Colin Green, Sch. of Arch., Duncan of Jordanstone College, Dundee, Scotland,U.K.

Chris Hohenemser, Dept. of Physics, Clark University, Worcester, Mass.

J. Wesley Hutchinson, Dept. of Psychology, Stanford University, Stanford, Ca.

Mark Layman, Decision Research, A Branch of Perceptronics, Eugene, Ore.

Sarah Lichtenstein, Decision Research, A Branch of Perceptronics, Eugene, Ore.

Michael Lindell, Battelle Human Affairs Research Ctr., Seattle, Wash.

Donald MacGregor, Decision Research, A Branch of Perceptronics, Eugene, Ore.

Doug MacLean, Ctr. for Philosophy & Public Policy, U. of Md., College Park, Md.

Harry Otway, Systems Analysis Div., Joint Research Ctr., Ispra, Italy

Randy Simpson, Office of Naval Research, Arlington, Virginia

Paul Slovic, Decision Research, A Branch of Perceptronics, Eugene, Ore.

Pieter Jan Stallen, TNO, Afdeling Beleidsstudies, Apeldoorn, The Netherlands

Adrian Tiemann, General Electric Corp. Research & Development, Schenectady, N.Y.

Charles Vlek, Inst. for Experimental Psychology, Haren, The Netherlands

Steven Withey, Survey Research Ctr., U. of Michigan, Ann Arbor, Mich.

Table 2

Agenda for the Risk Perception Workshop

Thursday, December 11th

9:00	9:10	Opening remarks
9:10	9:55	Presentation by Green & Brown
9:55	10:40	Presentation by Kenneth Craik
10:40	11:00	Coffee Break
11:00	11:45	Presentation by Vlek & Stallen
11:45	12:30	Presentation by Chris Hohenemser
12:30	2:00	Lunch
2:00	2:45	Presentation by Harry Otway
2:45	3:30	Presentation by Decision Research
3:30	4:00	Coffee Break
4:00	4:45	Presentation by Yale group
4:45	5:30	Presentation by Michigan group

Friday, December 12th

9:00	9:45	Presentation by Wes Hutchinson
9:45	10:30	Presentation by Battelle group
10:30	10:45	Coffee Break
10:45	11:15	Methodology: What hazards should be studied?*
11:15	11:45	Methodology: What groups of people should be studied?
11:45	12:30	Methodology: What sorts of tasks should be employed?
12:45	2:00	Lunch
2:00	2:45	Methodology: What characteristics of risk and benefit should be studied?
2:45	3:15	Methodology: What issues of data analysis must be considered?
3:15	3:30	Coffee Break
3:30	4:15	Methodology: Methods of analysis continued
4:15	5:00	Methodology: Other methodological issues

Dinner: On your own! Decision Researchers will provide advice and some transportation. Hospitality suite open later.

Saturday, December 13th

9:00	10:30	Summary of substantive results from research to date
10:30	10:45	Coffee Break
10:45	12:30	Policy implications of research on perceived risk
12:30	2:00	Lunch
2:00	3:30	Future directions
3:30	3:45	Coffee Break
3:45	5:00	Continued fights; neglected issues

* Some specific issues to be discussed in this and each of the remaining sessions are listed below.

Risk Analysis

Vol. 2, No. 2 June 1982

CONTENTS

Table 3. Issue of Risk Analysis that resulted from the workshop.

AGENDA: Suggested Topics for Discussion Within Each Session

Friday

10:45 - 11:15 What hazards should be studied?
- a. Large vs. small sets: Does it make a difference?
- b. Global (e.g., nuclear power; pesticides) vs. specific (having a nuclear power plant built in your neighborhood; DDT) representations
- c. Which particular hazards are important to study? What constitutes a "representative" set of hazards?
- d. Problems of order or context effects
- e. Other?

11:15 - 11:45 What groups of people should be studied?
- a. Interest groups vs. representative samapling of population or socioeconomic strata
- b. Pros and cons of studying legislators, regulators, industrialists, blue-collar workers, etc.

11:45 - 12:30 What sorts of tasks should be employed?
- a. Measure of riskiness, benefit, safety
- b. Can we measure acceptability of risk? Should we try?
- c. Risk regulation scales
- d. Fatality estimation
- e. Willingness to pay
- f. Scenarios—images of disaster
- g. What response modes are worthwhile? What are the relative merits of paired comparisons, magnitude estimation, category ratings, etc.?

2:00 - 2:45 What characteristics of hazards should be studied?
- a. Risk and benefit characteristics (e.g., voluntariness, economic benefit)
- b. Can risks and benefits be judged independently?
- c. Should biophysical, political, and managerial characteristics be assessed for various hazards?
- e. Is it meaningful to strive for a taxonomy of hazards? Are there multiple taxonomies? Should there be?

2:45 - 4:15 Data analysis issues
- a. What are the pros and cons of analyzing relationships
  1. Within subjects and across hazards
  2. Within hazards and across subjects
  3. Across hazards, using group means
- b. What are the pros and cons of factor analysis, cluster analysis, multidimensional scaling methods, tree representations, etc., for achieving the various objectives of risk perception studies?

4:15 - 5:00 Other methodological issues
- a. How, and how well, can the techniques developed for small-scale studies be translated into questions suitable for large-scale surveys?
- b. Should methodologies be standardized? Do variations in hazards, tasks and analyses illuminate or obscure what's going on?

Saturday

9:00 - 10:30 Summary of substantive results from research to date
- a. What are the results we agree with? What are the inconsistencies?
- b. Are people's risk perceptions accurate? Biased? Are their errors predictable? What are the cognitive processes underlying their judgments?
- c. How do perceptions of riskiness, benefit and various other characteristics of hazards interrlate?

10:45 - 12:30 Policy implications of research on perceived risk
- a. Can we draw valid policy recommendations from this research?
- b. If the answer to question a is yes, what are the implications for:
  1. Setting of safety standards, regulations, priorities for testing carcinogens?
  2. Forecasting the impact of various kinds of accidents or mishaps?
  3. Forecasting public acceptance of hazardous activities or technologies?
  4. Educating the public, informing citizens about risks, media coverage of hazards and accidents?
  5. Comparative risk analysis?
  6. Decision analysis?

2:00 - 3:30 Future directions
- a. What are the most important gaps in our knowledge?
- b. What are the priorities for future research?

3:45 - 5:00 Continued fights; neglected issues
? ? ? ?

Risk Analysis, Vol. 2, No. 2, 1982

APPENDIX

Why Study Risk Perception?

Paul Slovic,[1] Baruch Fischhoff,[1] and Sarah Lichtenstein[1]

Received March 3, 1982

Studies of risk perception examine the opinions people express when they are asked, in various ways, to characterize and evaluate hazardous activities and technologies. This research aims to aid risk analysis and societal decision making by (i) improving methods for eliciting opinions about risk, (ii) providing a basis for understanding and anticipating public responses to hazards, and (iii) improving the communication of risk information among laypeople, technical experts, and policy makers.

KEY WORDS: risk perception; risk assessment; risk management; risk policy; acceptable risk.

INTRODUCTION

For people and institutions in industrialized societies, the question "How safe is safe enough?" appears likely to be one of the major policy issues of the 1980s. The daily discovery of new hazards and the widespread publicity given them is causing more and more individuals to see themselves as the victims, rather than as the beneficiaries, of technology. These fears and the opposition to technology that they cause have puzzled and frustrated industry promoters and policy-makers, who believe that the public's pursuit of a "zero-risk" society threatens the nation's political and economic stability. Political Scientist Aaron Wildavsky[(1)] offers one expression of the technologists' concerns:

> How extraordinary! The richest, longest-lived, best-protected, most resourceful civilization, with the highest degree of insight into its own technology, is on its way to becoming the most frightened. Has there ever been, one wonders, a society that produced more uncertainty more often about everyday life? Is it our environment or ourselves that have changed? Would people like us have had this sort of concern in the past? ... today, there are risks from numerous small dams far exceeding those from nuclear reactors. Why is the one feared and not the other? Is it just that we are used to the old or are some of us looking differently at essentially the same sorts of experience?

Over the past few years, a small number of researchers have been attempting to answer such questions by examining the opinions that people express when they are asked, in a variety of ways, to evaluate hazardous activities and technologies. This research aims (i) to discover what people mean when they say that something is (or is not) "risky," and to determine what factors underlie those perceptions, (ii) to develop a theory of risk perception that predicts how people will respond to new hazards and management strategies (e.g., warning labels, regulations, substitutes), and (iii) to develop techniques for assessing the complex and subtle opinions that people have about risk. If successful, this research should aid policy-makers by improving communication between them and the lay public, anticipating public responses to experiences and events (e.g., a good safety record, an accident), and directing educational efforts.

[1]Decision Research, a branch of Perceptronics, Eugene, Oregon 97401.

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Within this program of research, Wildavsky's questions are just the tip of the iceberg. The broader agenda looks more like the following:

(1) What are the determinants of perceived risk? What are the concepts by which people characterize risks? How are those concepts related to their attitudes and behavior towards different technologies? Are perceptions of risk governed by interpretations of fact or are they also affected by emotional factors? Are perceptions really sensitive, as is often claimed, to factors such as the timing and controllability of risks, the dread they cause, or the equity with which they are distributed? How are perceptions affected by the methods used to assess them?

(2) How and why do laypersons' perceptions of risk differ from those of experts? How accurate are public perceptions? Are people so poorly informed (and uneducable) that they require paternalistic institutions to protect them? Would they be better off letting technical experts make most of the important decisions? Or do they know enough to be able to make their own decisions in the marketplace? When laypeople are in error, is it because they were poorly informed, because they were unable to do better, or because the environment was not structured so as to aid them properly?

(3) What information is needed to foster enlightened individual and social behavior with regard to risk issues? How and by whom should such information be presented to the public? What indices or criteria are useful for putting diverse risks in perspective? What are the roles of the news media and the schools in educating people about decision-making in general and technological risk in particular?

(4) What is the role of judgment in technical assessments of risk? When experts are forced to go beyond hard evidence and rely on educated intuition, do they encounter judgmental difficulties similar to those experienced by laypeople? How well do experts assess the limits of their own knowledge? How can technical judgments be improved?

(5) How do people perceive the benefits of risky technologies? Almost all questions asked about risk perceptions have analogs with benefit perceptions. How can the latter be measured and integrated with characteristics of risk to provide a more complete understanding of behavior?

(6) What determines the relative acceptability of hazardous technologies? How are assessments of their various risks and benefits combined subjectively? What role do considerations such as voluntariness, catastrophic potential, and equity play? What risk-benefit considerations motivate people to political action? Are some kinds of risks unacceptable, no matter what the expected benefits they bring?

(7) What makes a risk analysis "acceptable?" Some analyses are readily accepted and guide society's responses with a minimum of conflict, contradiction, and doubt. Others only fuel debate. Are the differences due to the specific hazards involved, the methods of analysis, the way people are involved in the decision-making process, or the way in which results are communicated?

THE PSYCHOMETRIC PARADIGM

Risk-perception research had its origins in studies of judgment and decision-making that began with attempts by Mosteller and Nogee[2], Edwards,[3, 4] Davidson, Suppes, and Siegel,[5] and Coombs and Pruitt,[6] to operationalize the axiomatic formulations of utility theory put forth by von Neumann and Morgenstern[7] and Savage.[8] The empirical research on probability assessment, utility assessment, and decision-making processes that these studies initiated continues to this day. A major development in this area was the discovery of a small set of mental strategies, or heuristics, that people employ in order to make sense out of an uncertain world.[9, 10] Although these rules are valid in some circumstances, in others they lead to large and persistent biases with serious implications for risk assessment.[11, 12]

Risk-perception research has been and continues to be grounded in basic cognitive psychology. In recent years, interest in the substantive issues unique to technological risks has led to the use of psychophysical scaling methods and multivariate analysis to produce quantitative representations of risk attitudes and perceptions.[11-24] Researchers employing this psychometric paradigm have typically asked people to judge the current and desired riskiness (or safety) of diverse sets of hazardous activities, substances, and technologies, and to indicate their desires for risk reduction and regulation of these hazards. These global judgments are then related to judgments about other properties, including: (i) the hazard's status on characteristics that have been hypothesized to account for risk perceptions and attitudes (e.g., voluntariness, dread, knowledge, controllability); (ii) the benefits that each hazard provides to society; (iii) the number

of deaths caused by the hazard in an average year; (iv) the number of deaths caused by the hazard in a disastrous year; and (v) the seriousness of each death from a particular hazard relative to a death due to other causes.

RESULTS

A number of systematic, replicable, and potentially important results have emerged from studies of risk perception. From the laboratory research on basic perceptions and cognitions, we have learned that difficulties in understanding probabilistic processes, biased media coverage, misleading personal experiences, and the anxieties generated by life's gambles cause uncertainty to be denied, risks to be misjudged (sometimes overestimated and sometimes underestimated), and judgments of fact to be held with unwarranted confidence.[11, 12] Unfortunately, experts' judgments appear to be prone to many of the same biases as those of laypersons, particularly when experts are forced to go beyond the limits of available data and rely upon their intuitions.[25] Research further indicates that disagreements about risk should not be expected to evaporate in the presence of evidence. Strong initial views are resistant to change because they influence the way that subsequent information is interpreted. New evidence appears reliable and informative if it is consistent with one's initial beliefs; contrary evidence tends to be dismissed as unreliable, erroneous, or unrepresentative.[26] When people lack strong prior opinions, the opposite situation exists—they are at the mercy of the problem formulation. Presenting the same information about risk in different ways buffets their perspectives and their actions like a ship in a storm.[27, 28]

Some observers, cognizant of the difficulties people have in comprehending and estimating risks, have concluded that the problems are insurmountable. We disagree. Although the broad outlines of the psychological research just described seem to support a pessimistic view, the details of that research give some cause for optimism. Upon closer examination, it appears that people understand some things quite well, although their path to knowledge may be quite different from that of the technical experts. In situations where misunderstanding is rampant, people's errors can often be traced to inadequate information and biased experiences, which education may be able to counter.

Research conducted within the psychometric paradigm yields further generalizations, among which are the following taken from our own work.

(1) Perceived risk is quantifiable and predictable. Psychometric techniques seem well suited for identifying similarities and differences among groups with regard to risk perceptions and attitudes.

(2) "Risk" means different things to different people. When experts judge risk, their responses correlate highly with technical estimates of annual fatalities. Laypeople can assess annual fatalities if they are asked to (and produce estimates not unlike the technical estimates). However, their judgments of risk are sensitive to other factors as well (e.g., catastrophic potential, threat to future generations) and, as a result, are not closely related to their own (or experts') estimates of annual fatalities.

(3) Even when groups disagree about the overall riskiness of specific hazards, they show remarkable agreement when rating those hazards on characteristics of risk such as knowledge, controllability, dread, catastrophic potential, etc.

(4) Many of these risk characteristics are highly correlated with each other, across a wide domain of hazards. For example, voluntary hazards tend also to be controllable and well known, hazards that threaten future generations tend also to be seen as having catastrophic potential, etc. Analysis of these interrelationships suggests that the broader domain of characteristics can be condensed to two or three higher-order characteristics or factors, which reflect the degree to which a risk is understood, the degree to which it evokes a feeling of dread, and the number of people exposed to the risk (see Fig. 1). This factor structure has been found to be similar across groups of laypersons and experts judging large and diverse sets of hazards. Making the set of hazards more specific (e.g., partitioning nuclear power into radioactive waste transport, uranium mining, nuclear reactor accidents, etc.) appears to have little effect on the factor structure or its relationship to risk perceptions.[2,19]

[2] The invariance obtained thus far with factor analytic studies does not imply, however, that approaches based on quite different methods and assumptions would also produce similar results. In fact, Tversky and Johnson[20] have shown that a very different hazard structure results from representations based on judgments about how similar one hazard is to another with respect to risk. The implications of such differences remain to be determined.

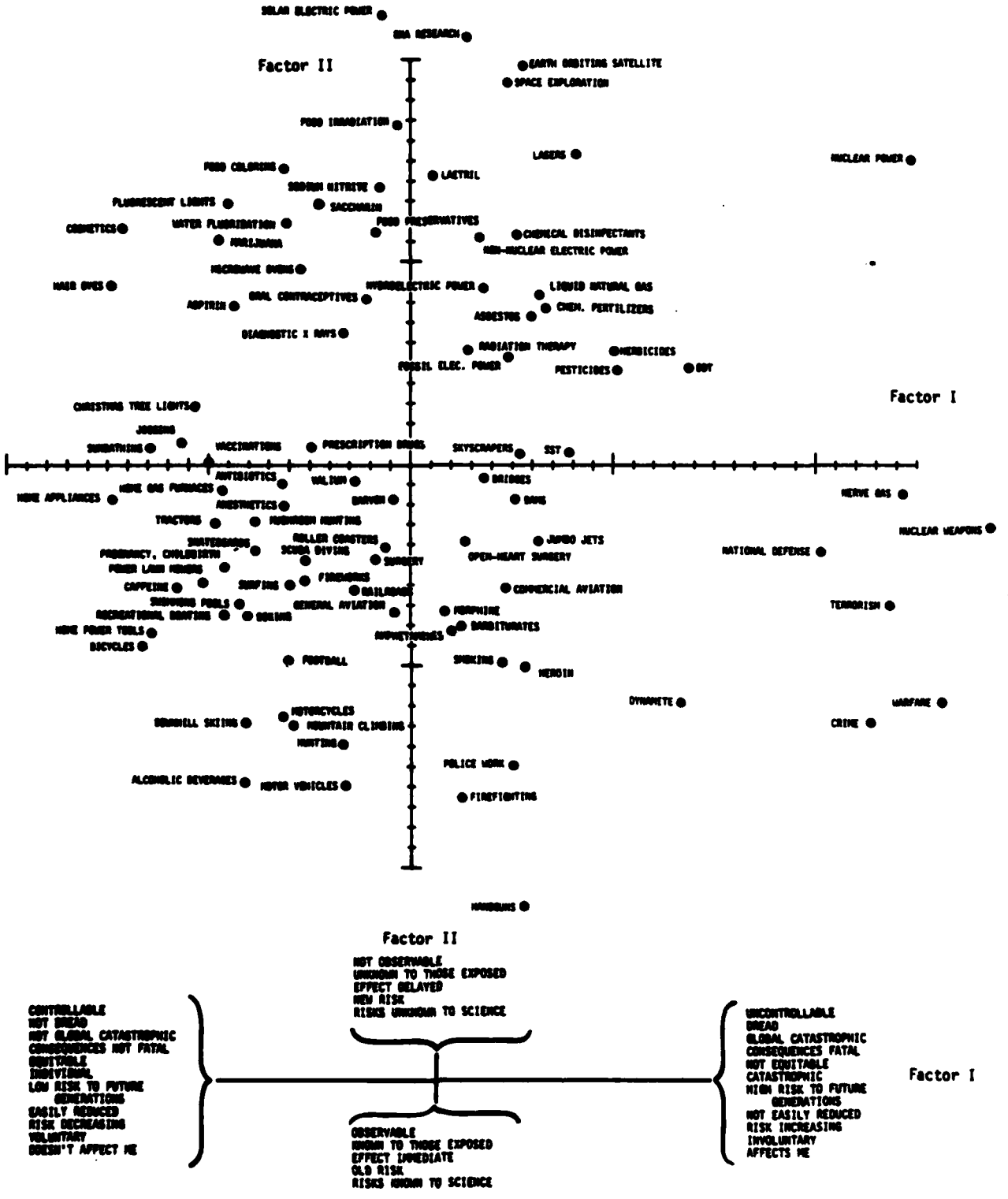

Fig. 1. Hazard locations on Factors 1 and 2 of the three-dimensional structure derived from the interrelationships among 18 risk characteristics. Factor 3 (not shown) reflects the number of people exposed to the hazard and the degree of one's personal exposure. The diagram beneath the figure illustrates the characteristics that comprise the two factors. Source: reference 12.

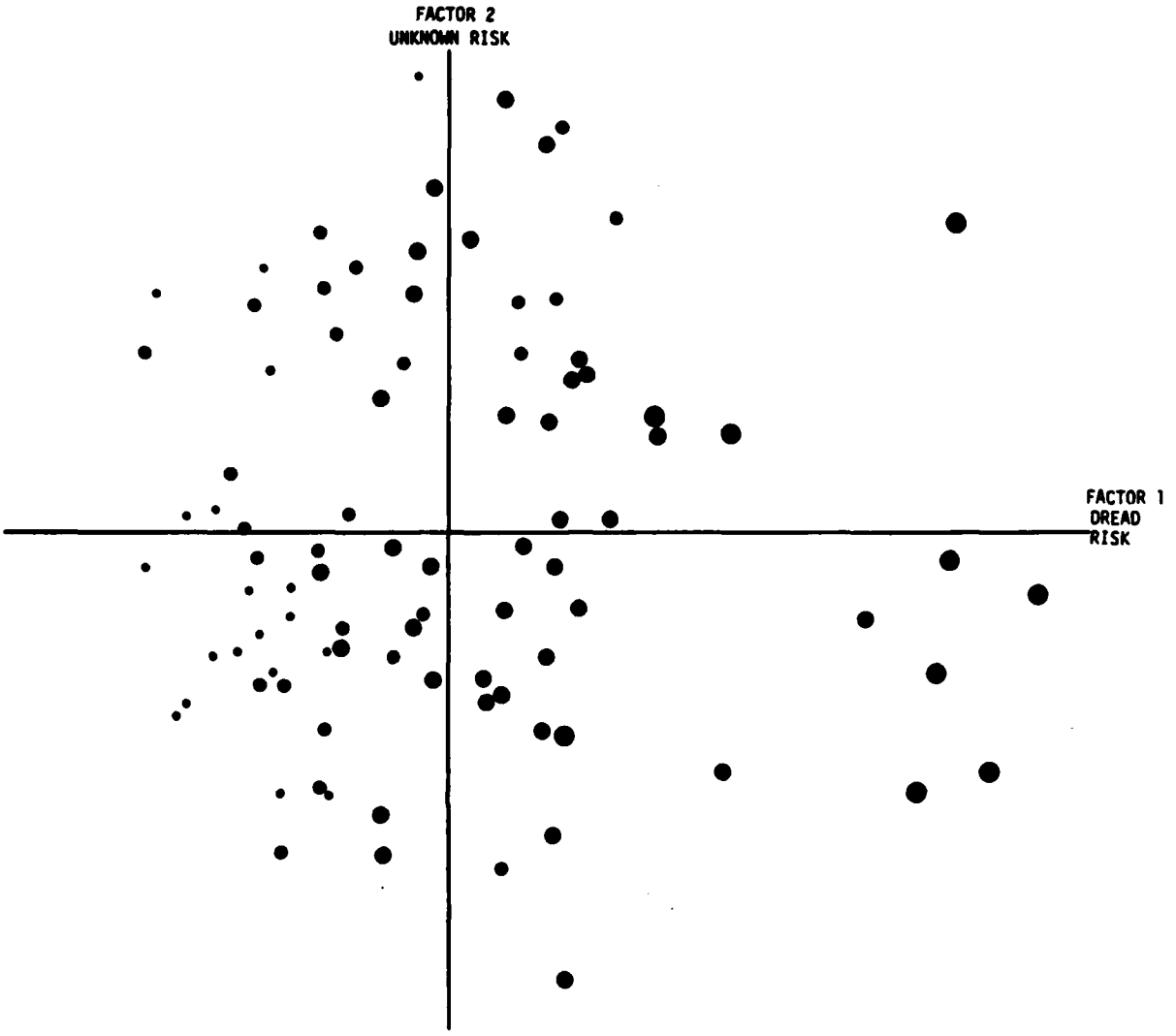

Fig. 2. Attitudes towards regulation of the hazards shown in Fig. 1. The larger the dot, the greater the desire for strict regulation to reduce risk. Source: reference 19.

(5) Many of the various characteristics, particularly those associated with the factor "Dread Risk," correlate highly with laypersons' perceptions of risk. The higher an activity's score on the dread factor, the higher its perceived risk, the more people want its risks reduced, and the more they want to see strict regulation employed to achieve the desired reductions in risk (see Fig. 2). The factor labeled "Unknown Risk" tends not to correlate highly with risk perception. Factor 3, "Exposure," is moderately related to lay perceptions of risk. In contrast, experts' perceptions of risk are *not* related to any of the various risk characteristics or factors derived from these characteristics.

(6) In agreement with hypotheses originally put forth by Starr[29] people's tolerance for risk appears related to their perception of benefit. All other things being equal, the greater the perceived benefit, the greater the tolerance for risk. Moreover, that tolerance depends upon the voluntariness of the activity. Unlike Starr, however, we have found that risk acceptability is also influenced by other characteristics such as familiarity, control, catastrophic potential, and uncertainty about the level of risk.

(7) The relative seriousness of losing N lives in a single mishap (as opposed to losing one life in each of N mishaps) cannot be adequately modeled by a weighting function or by an exponent applied to N.

Accidents serve as signals regarding the probability and magnitude of further mishaps. An accident that takes many lives may produce relatively little social disturbance if it occurs as part of a familiar and well-understood system (e.g., a train wreck). A small accident in an unfamiliar or poorly understood system may have immense consequences if it is perceived as a harbinger of further and possibly catastrophic mishaps.[12, 13]

CRITICISMS OF RISK-PERCEPTION RESEARCH

Although those of us studying risk perception are enthused about the progress and potential of this work, this line of research is not without its critics. Some of the criticism seems to us to be based on misconceptions of the results and their implications. In this section we shall briefly review and comment upon some of the concerns that have been raised in hopes of clarifying the purpose, strength, and limitations of risk-perception research.[3]

"Virtually anything can be a determiner of risk-perception"

We disagree. As indicated above, some speculations about correlations between judgments of riskiness and risk characteristics proved to be true upon empirical examination. Many other, however, did not. The characteristics associated with the factor labeled "Unknown Risk" showed little correlation with risk judgments, while the third factor, "Exposure," was only moderately related. And experts' judgments of risk were unrelated to any risk characteristics or factors (except annual mortality).

"When the experts rate 'risks,' are they not really just performing a test of their ability to recall the statistical tabulations that risk experts are expected to know?"

If taken at face value, this concern would vitiate our study of expert judgment.[11] However, the experts were not told to recall mortality statistics. Rather, they, like laypeople, were asked to rate "risk." It was their decision to equate risk with mortality statistics. The fact that laypeople did not do so is a nontrivial result warranting further examination. Descriptively, these differing conceptions of "risk" represent a source of miscommunication between experts and nonexperts. Prescriptively, they identify considerations (e.g., catastrophic potential, equity) that the public wishes to have included in risk decisions and which are not adequately represented in mortality statistics.

"The results of psychometric scaling methods lend support to notions indicating that there are 'Correct' answers (i.e., statistics or theoretical projections) against which perceptions can be calibrated"

As researchers who sometimes compare lay estimates of risk with technical estimates, we deny this charge. Our papers on risk perception argue that risk estimates always have a subjective element, that experts, too, make mistakes in judgment, and that laypeople are sensitive to important nonstatistical considerations that experts sometimes neglect. The value of *comparisons* between lay judgments and technical estimates is to illuminate areas of disagreements and to identify cases in which laypeople have not tracked statistics for which fairly good evidence is available.

"In view of the infinite number of attitude objects, and the perishable nature of the results (especially for new or volatile issues) such studies can provide information to the regulators that might be useful but not sufficient as a basis for firm policies"

We see no evidence for this assertion. Why should one expect attitudes towards catastrophic losses, equitable distribution of risks and benefits, transfer of risk onto future generations, etc., to be so perishable as to be insufficient for firm policies? Furthermore, why should policies necessarily be firm? If important social attitudes change, should not policies change as well?

"It is difficult to generalize from risk-perception research, except to say that the determinants of perception vary from object to object"

[3] We are indebted to Harry Otway for bringing many of these concerns to our attention.

This and related statements imply that the determinants of perception are too complex and too variable to be useful for policy-making. We disagree. As indicated in our brief survey of results, there is considerable stability across diverse groups of respondents and diverse sets of hazards. Furthermore, it is true that risk perception is a complex, multidetermined phenomenon, but the same could be said of every important aspect of behavior. More generally, we question the wisdom of refusing to study complicated problems.

"Use of psychometric methods tacitly accepts the notion that there is a level of acceptable risk"

Although we initially believed that this was the case, the force of our own evidence has led us to share the skepticism of others regarding the concept of an acceptable level of risk. We found that people would willingly make judgments of acceptable risk levels. However, slight changes in the scaling technique produced large changes in these judgments—a sharp contrast to studies of perceived risk, where changes in method typically make little difference. Further reflections led us to realize that the acceptable-risk concept itself is logically unsound.[31] Our society accepts activities or technologies, not risks. That acceptance depends on the costs and benefits of the technology in question and on the available alternatives. The variability of acceptable-risk judgments may be due to the fact that these factors are incompletely specified in psychometric studies. Whereas risks may be judged in isolation, acceptability is always context-dependent.

"Although risk-perception studies have produced some important insights, there is some question as to whether empirical research should have been necessary to get them; perhaps good common sense and professional judgment could have told us that to begin with"

The contributions of a discipline should not be evaluated by casual application of the "How surprising was that result?" test. Experiments by Fischhoff[32,33] have demonstrated that, in hindsight, people consistently exaggerate what could have been anticipated in foresight. Slovic and Fischhoff[34] showed that similar effects occur when people evaluate the predictability and informativeness of scientific results. Once they learn of an experiment's findings, people tend to believe they "knew all along" what the results would be. Reported results seem less surprising in hindsight than in foresight. Moreover, there is a sense in which experimentation forces us to think more deeply about a problem and alerts us to relationships that could have been discovered without empirical study but probably would not have been. For example, a study we conducted with college students showed that, across a large and representative sample of hazards, involuntary risks were also judged hard to control, catastrophic, and inequitable. These relationships imply that the aversion to involuntary risks observed by Starr[29] may be caused by other characteristics that are closely related to voluntariness. In retrospect, we did not need a survey of students to tell us about these relationships. We could have discovered them through "common sense and judgment." However, we did not. Nor did other researchers who have critiqued Starr's work (e.g., ref. 35).

POLICY IMPLICATIONS: A POSITIVE VIEW

We recognize that individual and societal response to hazards is multidetermined. Political, social, economic, and psychological factors interact with technical feasibility in complex and poorly understood ways. Nevertheless, we believe that research aimed at understanding how people think about risk has an important role in informing policy. Although we do not think that policy-makers should be guided by popularity, as indicated by surveys, we believe that studies of public attitudes could be used to highlight the concerns of people at risk and to forecast their reactions to hazards and their management. It would surprise and disturb us to learn that policy-makers did not want to understand these reactions and concerns and consider them in their deliberations. Psychometric knowledge may not ensure wise or effective decisions, but lack of such knowledge certainly increases the probability that well-intentioned policies will fail to meet their goals.

What follows is a brief overview of some specific attempts to provide policy-relevant knowledge.

National Flood Insurance Program

There has been a great deal of governmental concern over the fact that, whereas few residents of

flood and earthquake areas voluntarily insure themselves against the consequences of such disasters, many turn to the federal government for aid after suffering losses.[36] Policy-makers have argued that both the government and the property owners at risk would be better off financially under a federal insurance program. Such a program would shift the burden of disasters from the general taxpayer to individuals living in hazardous areas and would thus promote wiser decisions regarding the use of floodplains.

Without a firm understanding of how people perceive and react to risks, however, there is no way of knowing what sort of disaster-insurance program would be most effective. For example, it seems reasonable to expect that lowering the cost of such insurance would stimulate people to buy it, yet there is evidence that people do not voluntarily purchase flood insurance even when the rates are highly subsidized.

Research on this topic by Kunreuther *et al.*[36] and Slovic *et al.*[37] aimed to determine the critical factors influencing the voluntary purchase of insurance against the consequences of low-probability events such as floods or earthquakes. A combination of laboratory experiments and field survey methods was employed. Analysis of the survey data revealed a great deal of ignorance and misinformation regarding the availability and terms of insurance and the probabilities of damage from a future disaster. The laboratory experiments showed that people preferred to insure against relatively high-probability, low-loss hazards and tended to reject insurance in situations where the probability of loss was low and the potential losses were high. These results suggest that people's natural predispositions run counter to economic theory (e.g., ref. 38), which assumes that risk-averse individuals should desire a mechanism to protect them from rare catastrophic losses.

When asked about their insurance decisions, subjects in both the laboratory and survey studies indicated a disinclination to worry about low-probability hazards. Such a strategy is understandable in view of the fact that limitations of people's time, energy, and attentional capacities create a finite reservoir of concern. Unless we ignored many low-probability threats we would become so burdened that any sort of productive life would become impossible. Another insight gleaned from the experiments and the survey is that people think of insurance as an investment. Making claims and receiving payments (by insuring against more probable losses) seems to be viewed as a return on the premium, hence "a good investment." The popularity of low-deductible insurance plans[39, 40] provides confirmation from outside the laboratory of the preference for insuring against probable events with small consequences.

This research led us to conclude that the primary cause of failure in the disaster insurance market is lack of consumer interest. If insurance is to be marketed on a voluntary basis, then consumers' attitudes and information-processing limitations must be taken into account. Policy-makers and insurance-providers must find ways to communicate the risks and arouse concern for the hazards. One method found to work in the laboratory experiments is to increase the perceived probability of disaster by lengthening the individual's time horizon. For example, considering the risk of experiencing a 100-year flood at least once during a 25-year period, instead of considering the risk in one year, raises the probability to .22 and may thus cast flood insurance in a more favorable light. Another step would have insurance agents play an active role in educating homeowners about the proper use of insurance as a protective mechanism and providing information about the availability of insurance, rate schedules, deductible values, etc. Of course, these actions may not be effective. It may also be necessary to institute some form of mandatory coverage. Recognizing the difficulty of inducing voluntary coverage, the National Flood Insurance Program now requires insurance as a condition for obtaining federal money to build in flood-prone areas.

Seat Belts

Another form of insurance that people do not often use is the automobile seat belt. Promotional efforts to get motorists to wear seat belts have failed dismally.[41] In the wake of expensive advertising campaigns and buzzer systems, fewer than 15% of all motorists "buckle up for safety." Policy-makers have criticized the public for failing to appreciate the risks of driving and the benefits of seat belts. However, results from risk-perception research provide an alternative perspective that seems at once more respectful of drivers' reasoning and more likely to increase seat belt use. As noted in the previous section, people often disregard very small probabilities. By like token, motorists' reluctance to wear seat belts might be due to the extremely small probability of incurring a fatal

accident on a single automobile trip. Because a fatal accident occurs only about once in every 3.5 million person-trips and a disabling injury only once in every 100,000 person-trips, refusing to buckle one's seat belt may seem quite reasonable. It may look less reasonable, however, if one adopts a multiple-trip perspective. This is, of course, the perspective of traffic safety planners, who see the 10,000 or so lives that might be saved annually if everybody on every trip buckled up. For the individual driver, over 50 years of driving (about 40,000 trips), the probability of being killed is .01 and the probability of experiencing at least one disabling injury is .33. In experiments, we have found that people induced to consider this lifetime perspective responded more favorably toward the use of seat belts (and to air bags) than did people asked to consider a trip-by-trip perspective.[42] More recent studies suggest that television and radio messages based on this lifetime-cumulative-risk theme will effectively increase actual seat belt use.[43]

Forecasting Public Response: The Case of Nuclear Power

As Alvin Weinberg[44] observed, "...the public perception and acceptance of nuclear energy...has emerged as the most critical question concerning the future of nuclear energy." The reasonableness of these perceptions has been the topic of an extensive public debate, filled with charges and countercharges. For example, one industry source has argued that public reaction to Three Mile Island has cost "...as much as $500 billion...and is one measure of the price being paid as a consequence of fear arising out of an accident that according to the most thorough estimates may not have physiologically hurt even one member of the public."[45]

Risk-perception research offers some promise of clarifying the concerns of opponents of nuclear power.[46] In particular, psychometric studies show that these people judge its benefits as quite low and its risks as unacceptably great. On the benefit side, most opponents do not see nuclear power as a vital link in meeting basic energy needs; rather, they view it as a supplement to other sources of energy which are themselves adequate. On the risk side, nuclear power occupies a unique position in the factor space, reflecting people's views that its risks are unknown, dread, uncontrollable, inequitable, catastrophic and likely to affect future generations (see Fig. 1). Opponents recognize that few people have died to date as a result of nuclear power. However, they do have great concern over the potential for catastrophic accidents. Further analyses have suggested that opposition to nuclear power can be understood in terms of basic psychological principles of perception and cognition and is not likely to be changed by information campaigns that focus on safety; however, information about benefits may have some impact. Opposition might well ease if the industry maintains a superb safety record or energy shortages occur. But because nuclear risks are perceived to be unknown and potentially catastrophic, even small accidents will have immense social costs, a fact that has direct implications for the setting of safety standards.[30]

This type of research may also forecast the response to technologies that have yet to catch the public's eye. For example, our studies indicate that recombinant DNA technology shares several of the characteristics that make nuclear power so hard to manage.[19] If it somehow seizes public attention, this new technology could face some of the same problems and opposition now confronting the nuclear industry.

COMPARING RISKS

One frequently advocated approach to deepening people's perspectives is to present quantified risk estimates for a variety of hazards, expressed in some unidimensional index of death or disability, such as risk per hour of exposure,[47] annual probability of death,[48] or reduction in life expectancy.[49, 50] Even though such comparisons have no logically necessary implications as guides to decision making,[31] one might still hope that they would help improve people's intuitions about the magnitude of risks. Risk-perception research suggests, however, that these comparisons will often not be very satisfactory. People's perceptions and attitudes are determined not only by the sort of unidimensional statistics used in such tables but also by a variety of quantitative and qualitative characteristics—including a hazard's degree of controllability, the dread it evokes, its catastrophic potential, and the equity of its distribution of risks and benefits. To many people, statements such as "the annual risk from living near a nuclear power plant is equivalent to the risk of riding an extra three

miles in an automobile" give inadequate consideration to the important differences in the nature of the risks from these two technologies. In short, "riskiness" means more to people than "expected number of fatalities." Attempts to characterize, compare, and regulate risks must be sensitive to the broader conception of risk that underlies people's concerns.

THE ROLE OF RISK PERCEPTION IN A DEMOCRATIC SOCIETY

Concern about the nature of a society in which leaders are prisoners of public opinion and popularity polls is longstanding.[51] However, the risks of studying risk perceptions need to be compared with the risks of not studying them.

One alternative is not to listen to the public at all. Advocates of this position might argue that the public is too ill-informed and uneducable to provide useful input to risk decisions, which might better be made by paternalistic government organizations or a technical elite. Those who adopt this position out of political convenience rather than intellectual conviction might be loath to have research be conducted that could reveal that laypeople are not stupid, that experts have judgmental problems as well, or that public opinion is quite stable on some issues.

A second alternative is to consider public opinion, but not to study it. Many pundits and politicians would like their assertions about what the public knows and wants to stand as unchallenged facts. When such assertions are advanced to achieve a particular strategic advantage, their acceptance can distort the political process. Even when these assertions represent honest speculations about human behavior, the lack of substantiating research may increase the probability that well-intentioned policies will prove ineffective.

A third alternative is to study public opinions, but without asking people directly to express their views. Some economists, for example, argue that people's verbal expressions are poor indicators of their true preferences; one should always observe some actual behavior. Although appealing in principle, this position runs into difficulty because of the large number of untested assumptions needed to infer preferences from behavior.[31]

In this light, a risk-perception researcher's articles of faith would include: (i) asking people how they view technological hazards is a valid component of representative government; (ii) understanding and anticipating people's responses to hazards and their management can help reduce expenditures, delays, frustration, and enmity; and (iii) studying risk perception is an important step towards achieving this understanding.

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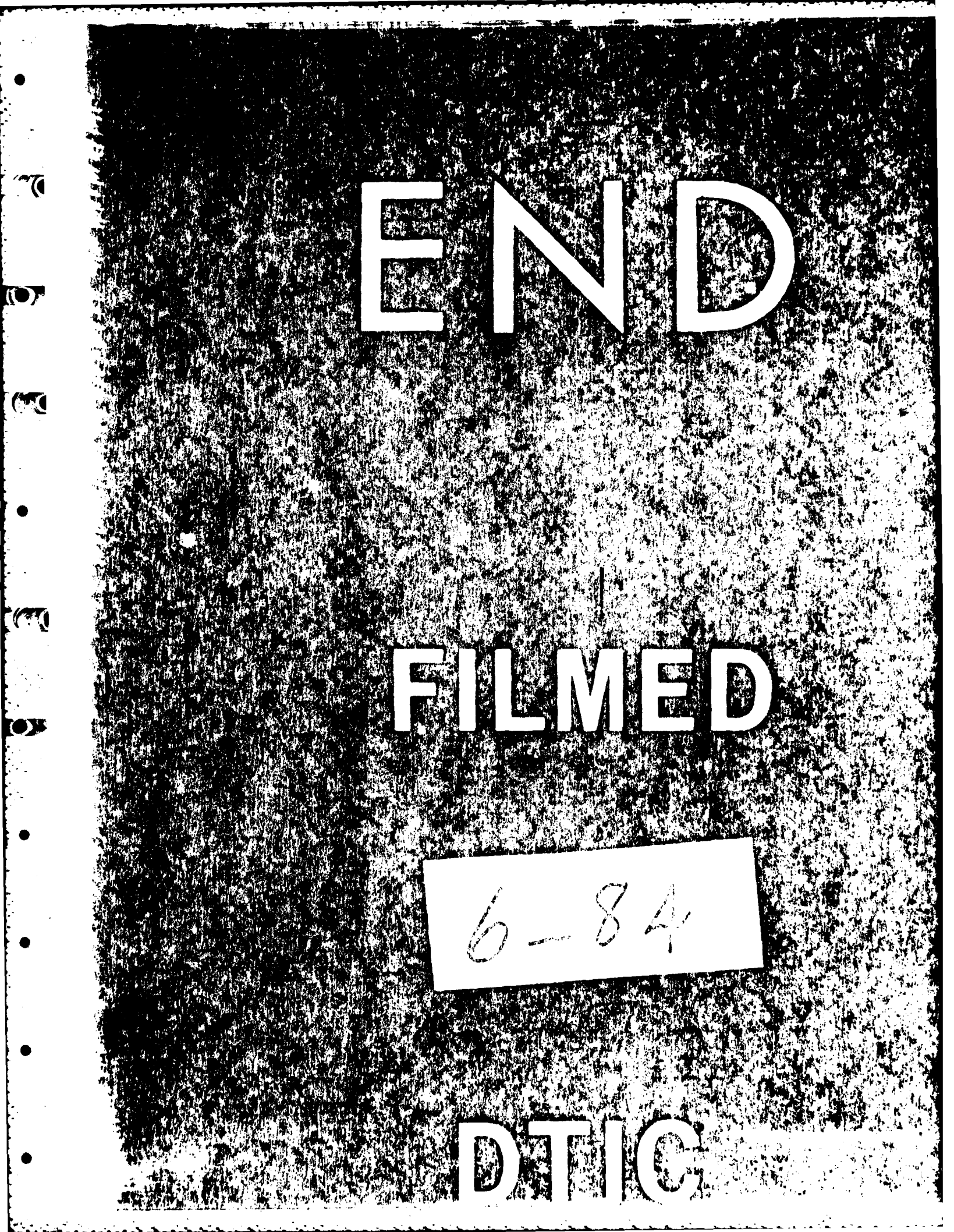
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